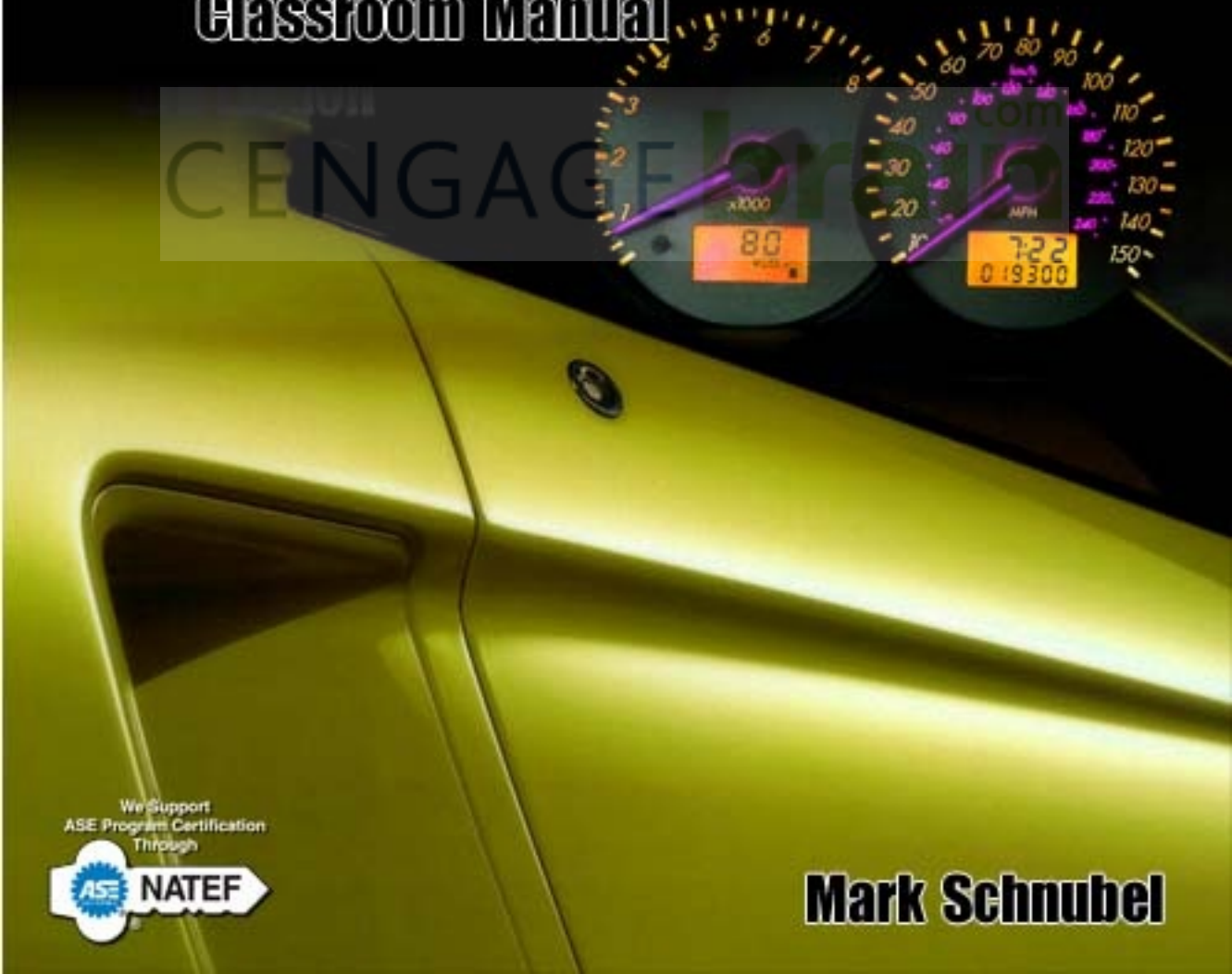
TODAY'S TECHNICIAN

Advanced Engine Performance

Classroom Manual



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Mark Schnubel

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Today's Technician: Advanced Engine Performance Shop Manual

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CHAPTER 1

Safety and Shop Practices

Upon completion and review of this chapter, you should be able to:

- ❑ Recognize shop hazards and take the necessary steps to avoid personal injury or property damage.
- ❑ Explain the purposes of the Occupational Safety and Health Act (OSHA).
- ❑ Identify the necessary steps for personal safety in the automotive shop.
- ❑ Describe the reasons for prohibiting drug and alcohol use in the shop.
- ❑ Explain the steps required to provide electrical safety in the shop.
- ❑ Define the steps required to provide safe handling and storage of gasoline.
- ❑ Describe the necessary housekeeping safety steps.
- ❑ Explain the essential general shop safety practices.
- ❑ Define the steps required to provide fire safety in the shop.
- ❑ Describe a typical fire extinguisher operating procedure.
- ❑ Explain four different types of fires and the type of fire extinguisher required for each type of fire.
- ❑ Describe three other pieces of shop safety equipment other than fire extinguishers.
- ❑ Follow proper safety precautions while handling hazardous waste materials.
- ❑ Dispose of hazardous waste materials in accordance with state and federal regulations.
- ❑ Describe three requirements for shop layout and explain why these requirements are important.
- ❑ Observe all shop rules when working in the shop.
- ❑ Observe all personal safety precautions while working in the automotive shop.
- ❑ Demonstrate proper lifting procedures and precautions.
- ❑ Demonstrate proper vehicle lift operating and safety procedures.
- ❑ Observe all safety precautions when hydraulic tools are used in the automotive shop.
- ❑ Follow the recommended procedure while operating hydraulic tools such as presses, floor jacks, and vehicle lifts to perform automotive service tasks.
- ❑ Follow safety precautions regarding the use of power tools.
- ❑ Demonstrate proper safety precautions during the use of compressed air equipment.
- ❑ Follow safety precautions while using cleaning equipment in the automotive shop.
- ❑ Operate vehicles in the shop according to shop driving rules.
- ❑ Observe all shop housekeeping rules.
- ❑ Follow the necessary procedures to maintain satisfactory shop air quality.
- ❑ Fulfill employee obligations when working in the shop.
- ❑ Accept job responsibilities for each job completed in the shop.
- ❑ Describe the ASE technician testing and certification process, including the eight areas of certification.

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Occupational Safety and Health Act

The Occupational Safety and Health Act (OSHA) regulates working conditions in the United States.

The Occupational Safety and Health Act (OSHA) was passed by the United States government in 1970. The purposes of this legislation are:

1. To assist and encourage the citizens of the United States in their efforts to assure safe and healthful working conditions by providing research, information, education, and training in the field of occupational safety and health.
2. To assure safe and healthful working conditions for working men and women by authorizing enforcement of the standards developed under the Act.

Since approximately 25 percent of workers are exposed to health and safety hazards on the job, the OSHA is necessary to monitor, control, and educate workers regarding health and safety in the workplace. Employers and employees should be familiar with workplace hazardous materials information systems (WHIMS).

Shop Hazards

Shop hazards must be recognized and avoided to prevent personal injury.

Service technicians and students encounter many hazards in an automotive shop. When these hazards are known, basic shop safety rules and procedures must be followed to avoid personal injury. Some of the hazards in an automotive shop are:

1. Flammable liquids such as gasoline and paint must be handled and stored properly.
2. Flammable materials such as oily rags must be stored properly to avoid a fire hazard.
3. Batteries contain a corrosive sulfuric acid solution and produce explosive hydrogen gas while charging.
4. Loose sewer and drain covers may cause foot or toe injuries.
5. Caustic liquids, such as those in hot cleaning tanks, are harmful to skin and eyes.
6. High-pressure air in the shop compressed air system can be very dangerous if it penetrates the skin and enters the bloodstream.
7. Frayed cords on electric equipment and lights may result in severe electrical shock.
8. Hazardous waste material such as batteries and the caustic cleaning solution from a hot or cold cleaning tank must be handled properly to avoid harmful effects.
9. Carbon monoxide (CO) from vehicle exhaust is poisonous.
10. Loose clothing or long hair may become entangled in rotating parts on equipment or vehicles, resulting in serious injury.
11. Dust and vapors generated during some repair jobs are harmful. Asbestos dust generated during brake lining service and clutch service is a contributor to lung cancer.
12. High noise levels from shop equipment such as an air chisel may be harmful to the ears.
13. Oil, grease, water, or parts cleaning solutions on shop floors may cause someone to slip and fall, resulting in serious injury.

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Safety in the Automotive Shop

Personal injury, vehicle damage, and property damage must be avoided by following safety rules regarding personal protection, substance abuse, electrical safety, gasoline safety, housekeeping safety, fire safety, and general shop safety.

Each person in an automotive shop must follow certain basic shop safety rules to remove the danger from shop hazards. When all personnel in the automotive shop follow these basic shop safety rules, personal injury, vehicle damage, and property damage may be prevented.

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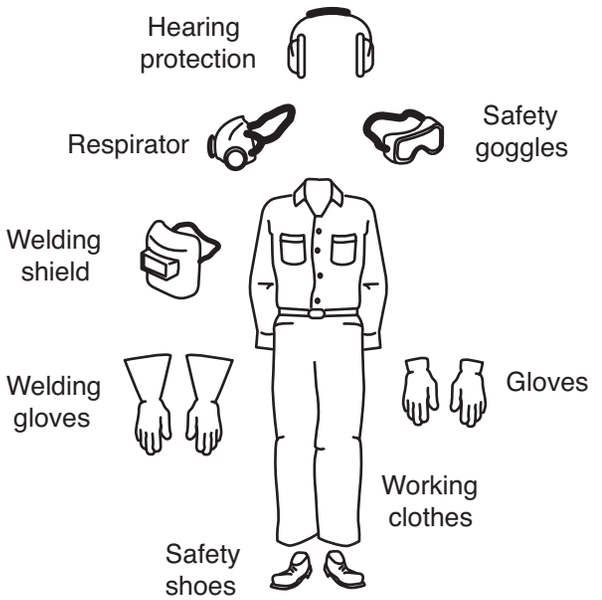

Figure 1-1 Shop safety equipment, including safety goggles, respirator, welding shield, proper work clothes, ear protection, welding gloves, work gloves, and safety shoes.

Personal Protection

1. Always wear safety glasses or a face shield in the shop (Figure 1-1).
2. Wear ear plugs or covers if high noise levels are encountered.
3. Always wear boots or shoes that provide adequate foot protection. Heavy-duty work boots or shoes with steel toe caps are best for working in the automotive shop. Footwear must protect against heavy falling objects, flying sparks, and corrosive liquids. Soles on footwear must protect against punctures by sharp objects. Runners and street shoes are not recommended in the shop.
4. Do not wear watches, jewelry, or rings when working on a vehicle. Severe burns occur when jewelry makes contact between an electrical terminal and ground. Jewelry may catch on an object, resulting in painful injury.
5. Do not wear loose clothing, and keep long hair tied behind your head. Loose clothing and long hair are easily entangled in rotating parts.
6. Wear a respirator to protect your lungs when working in dusty conditions.

Smoking, Alcohol, and Drugs in the Shop

Do not smoke when working in the shop. If the shop has designated smoking areas, smoke only in these areas. Do not smoke in customers' cars. A nonsmoker may not appreciate cigarette odor in his or her car. A spark from a cigarette or lighter may ignite flammable materials in the work place. The use of drugs or alcohol must be avoided while working in the shop. Even a small amount of drugs or alcohol affects reaction time. In an emergency situation, slow reaction time may cause personal injury. If a heavy object falls off the work bench and your reaction time is slowed by drugs or alcohol, you may not get your foot out of the way in time, resulting in a foot injury. When a fire starts in the workplace and you are a few seconds slower putting a fire extinguisher into operation because of alcohol or drug use, it could make the difference between extinguishing a fire and having expensive fire damage.

The improper or excessive use of alcoholic beverages and/or drugs may be referred to as substance abuse.

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Electrical Safety

1. Frayed cords on electrical equipment must be replaced or repaired immediately.
2. All electrical cords from lights and electrical equipment must have a ground connection. The ground connector is the round terminal in a three-prong electrical plug. Do not use a two-prong adapter to plug in a three-prong electrical cord. Three-prong electrical outlets should be mandatory in all shops.
3. Do not leave electrical equipment running and unattended.

Gasoline Safety

Gasoline is a very explosive liquid! One exploding gallon of gasoline has a force equal to fourteen sticks of dynamite. It is the expanding vapors from gasoline that are extremely dangerous. These vapors are present even in cold temperatures. Vapors formed in gasoline tanks on cars are controlled, but vapors from a gasoline storage can may escape from the can, resulting in a hazardous situation. Therefore, gasoline storage containers must be placed in a well-ventilated space.

Approved gasoline storage cans have a flash-arresting screen at the outlet (Figure 1-2). These screens prevent external ignition sources from igniting the gasoline within the can while the gasoline is being poured. Follow these safety precautions regarding gasoline containers:

1. Always used approved gasoline containers that are painted red for proper identification.
2. Do not fill gasoline containers completely full. Always leave the level of gasoline at least 1 inch from the top of the container. This action allows expansion of the gasoline at higher temperatures. If gasoline containers are completely full, the gasoline will expand when the temperature increases. This expansion forces gasoline from the can and creates a dangerous spill.
3. If gasoline containers must be stored, place them in a well-ventilated area such as a storage shed. Do not store gasoline containers in your home or in the trunk of a vehicle.

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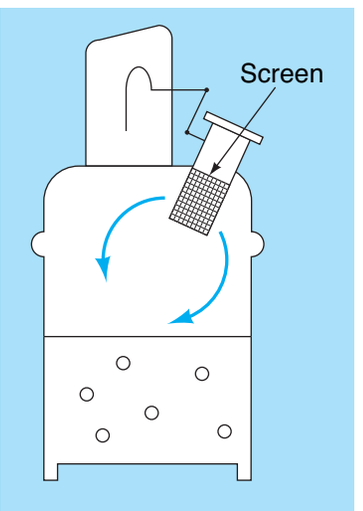

Figure 1-2 An approved gasoline container.

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4. When a gasoline container must be transported, be sure it is secured against upsets.
5. Do not store a partially filled gasoline container for long periods of time because it may give off vapors and produce a potential danger.
6. Never leave gasoline containers open except while filling or pouring gasoline from the container.
7. Do not prime an engine with gasoline while cranking the engine.
8. Never use gasoline as a cleaning agent.

Housekeeping Safety

1. Keep shop floors clean! Always clean shop floors immediately after a spill.
2. Store paint and other flammable liquids in a closed steel cabinet (Figure 1-3).
3. Oily rags must be stored in approved, covered garbage containers (Figure 1-4). A slow generation of heat occurs from oxidation of oil on these rags. Heat may continue to be generated until the ignition temperature is reached. The oil and the rags then begin to burn, causing a fire. This action is called spontaneous combustion. However, if the oily rags are in an airtight, approved container, the fire cannot receive enough oxygen to cause burning.
4. Keep the shop neat and clean. Always pick up tools and parts, and do not leave creepers lying on the floor.
5. Keep the workbenches clean. Do not leave heavy objects, such as used parts, on the bench after you are finished with them.

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Figure 1-3 Paints and combustible material containers must be kept in an approved safety cabinet.

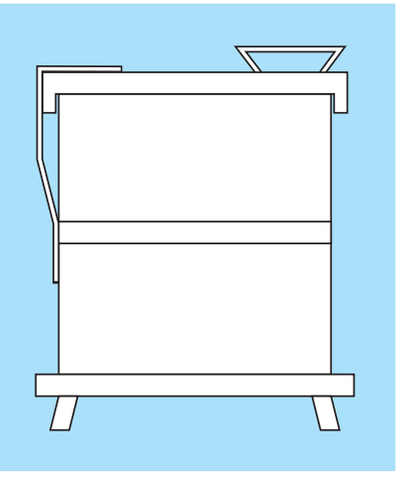

Figure 1-4 Oily rags must be stored in approved airtight containers.

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General Shop Safety

1. All sewer covers must fit properly and be kept securely in place.
2. Always wear a face shield, protective gloves, and protective clothing when necessary. Gloves should be worn when working with solvents and caustic solutions, handling hot metal, or grinding metal. Various types of protective gloves are available. Shop coats and coveralls are the most common types of protective clothing.
3. Never direct high-pressure air from an air gun against human flesh. If this action is allowed, air may penetrate the skin and enter the bloodstream, causing serious health problems or death. Always keep air hoses in good condition. If an end blows off an air hose, the hose may whip around and cause personal injury. Use only OSHA-approved air gun nozzles.
4. Handle all hazardous waste materials according to state and federal regulations. (These regulations are explained later in this chapter.)
5. Always place a shop exhaust hose on the tailpipe of a vehicle if the engine is running in the shop, and be sure the shop exhaust fan is turned on.
6. Keep hands, long hair, and tools away from rotating parts such as fan blades and belts on running engines. Remember that an electric-drive fan may start turning at any time.
7. When servicing brakes or clutches from manual transmissions, always clean asbestos dust from these components with an approved **asbestos dust vacuum cleaner**.
8. Always use the correct tool for the job. For example, never strike a hardened steel component, such as a piston pin, with a steel hammer. This type of component may shatter, and fragments can penetrate eyes or skin.
9. Follow the car manufacturer's recommended service procedures.
10. Be sure that the shop has adequate ventilation.
11. Make sure the work area has adequate lighting.
12. Use trouble lights with steel or plastic cages around the bulb. If an unprotected bulb breaks, it may ignite flammable materials in the area.
13. When servicing a vehicle, always apply the parking brake and place the transmission in park with an automatic transmission or neutral with a manual transmission if the engine is running. When the engine is stopped, place the transmission in park with an automatic transmission or reverse with a manual transmission.
14. Avoid working on a vehicle parked on an incline.
15. *Never work under a vehicle unless the vehicle chassis is supported securely on jack stands.*
16. When one end of a vehicle is raised, place wheel chocks on both sides of the wheels remaining on the floor.
17. Be sure that you know the location of shop first-aid kits, eyewash fountains, and fire extinguishers.
18. Collect oil, fuel, brake fluid, and other liquids in the proper safety containers.
19. Use only approved cleaning fluids and equipment. Do not use gasoline to clean parts.
20. Obey all state and federal safety, fire, and hazardous material regulations.
21. Always operate equipment according to the equipment manufacturer's recommended procedure.
22. Do not operate equipment unless you are familiar with the correct operating procedure.
23. Do not leave running equipment unattended.
24. Be sure the safety shields are in place on rotating equipment.

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25. All shop equipment must have regularly scheduled maintenance and adjustment.
26. Some shops have safety lines around equipment; always work within these lines when operating equipment.
27. Be sure that shop heating equipment is well ventilated.
28. Do not run in the shop or engage in horseplay.
29. Post emergency phone numbers near the phone. These numbers should include a doctor, ambulance, fire department, hospital, and police.
30. Do not place hydraulic jack handles where someone can trip over them.
31. Keep aisles clear of debris.

Fire Safety

1. Familiarize yourself with the location and operation of all shop fire extinguishers.
2. If a fire extinguisher is used, report it to management so the extinguisher can be recharged.
3. Do not use any type of open flame heater to heat the work area.
4. Do not turn the ignition switch on or crank the engine with a gasoline line disconnected.
5. Store all combustible materials such as gasoline, paint, and oily rags in approved safety containers.
6. Clean up gasoline, oil, or grease spills immediately.
7. Always wear clean shop clothes. Do not wear oil-soaked clothes.
8. Do not allow sparks and flames near batteries.
9. Welding tanks must be securely fastened in an upright position.
10. Do not block doors, stairways, or exits.
11. Do not smoke when working on vehicles.
12. Do not smoke or create sparks near flammable materials or liquids.
13. Store combustible shop supplies, such as paint, in a closed steel cabinet.
14. Store gasoline in approved safety containers.
15. If a gasoline tank is removed from a vehicle, do not drag the tank on the shop floor.
16. Know the approved fire escape route from your classroom or shop to the outside of the building.
17. If a fire occurs, do not open doors or windows. This action creates extra draft that makes the fire worse.
18. Do not put water on a gasoline fire because the water will make the fire worse.
19. Call the fire department as soon as a fire begins, and then attempt to extinguish the fire.
20. If possible, stand 6 to 10 feet from the fire and aim the fire extinguisher nozzle at the base of the fire with a sweeping action.
21. If a fire produces a great deal of smoke in the room, remain close to the floor to obtain oxygen and avoid breathing smoke.
22. If the fire is too hot or the smoke makes breathing difficult, leave the building.
23. Do not reenter a burning building.

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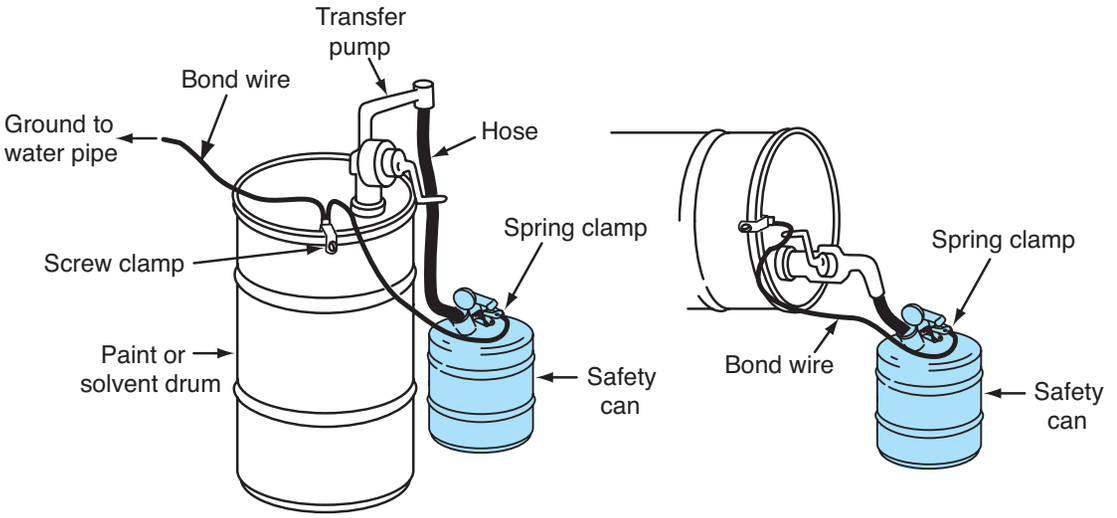

Figure 1-5 Safe procedures for flammable liquid transfer.

24. Keep solvent containers covered except when pouring from one container to another. When flammable liquids are transferred from bulk storage, the bulk container should be grounded to a permanent shop fixture such as a metal pipe. During this transfer process, the bulk container should be grounded to the portable container (Figure 1-5). These ground wires prevent the buildup of a static electric charge, which could result in a spark and disastrous explosion. Always discard or clean empty solvent containers because fumes in these containers are a fire hazard.
25. Familiarize yourself with different types of fires and fire extinguishers, and know the type of extinguisher to use on each fire.

Shop Safety Equipment

Fire Extinguishers

Shop safety equipment must be easily accessible and in good working condition.

Fire extinguishers are one of the most important pieces of safety equipment. All shop personnel must know the location of the fire extinguishers in the shop. If you have to waste time looking for an extinguisher after a fire starts, the fire could become out of control before you put the extinguisher into operation. Fire extinguishers should be located where they are easily accessible at all times. Everyone working in the shop must know how to operate the fire extinguishers. There are several different types of fire extinguishers, but their operation usually involves these steps:

1. Get as close as possible to the fire without jeopardizing your safety.
2. Grasp the extinguisher firmly and aim the extinguisher at the fire.
3. Pull a pin from the extinguisher handle.
4. Squeeze the handle to dispense the contents of the extinguisher.
5. Direct the fire extinguisher nozzle at the base of the fire and dispense the contents of the extinguisher with a sweeping action back and forth across the fire. Most extinguishers discharge their contents in 8 to 25 seconds.

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6. Always be sure the fire is extinguished.
7. Always keep an escape route open behind you so a quick exit is possible if the fire becomes out of control.

A decal on each fire extinguisher identifies the type of chemical in the extinguisher and provides operating information (Figure 1-6). Shop personnel should be familiar with the following types of fires and fire extinguishers:

1. Class A fires are those involving ordinary combustible materials such as paper, wood, clothing, and textiles. Multipurpose dry chemical extinguishers are used on these fires.
2. Class B fires involve the burning of flammable liquids such as gasoline, oil, paint, solvents, and greases. These fires may be extinguished with multipurpose dry chemical extinguishers. Fire extinguishers containing halogen, or halon, may be used to extinguish class B fires. The chemicals in this type of extinguisher attach to the hydrogen, hydroxide, and oxygen molecules to stop the combustion process almost instantly. However, the resultant gases from the use of halogen-type extinguishers are very toxic and harmful to the operator of the extinguisher.
3. Class C fires involve the burning of electrical equipment such as wires, motors, and switches. These fires may be extinguished with multipurpose dry chemical extinguishers.
4. Class D fires involve the combustion of metal chips, turnings, and shavings. Dry chemical extinguishers are the only type of extinguisher recommended for these fires.

Figure 1-6 Types and sizes of fire extinguishers.

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TABLE 1-1 FIRE EXTINGUISHER SELECTION
(Courtesy of General Fire Extinguisher Corporation)

FIRES	TYPE	USE	OPERATION
A CLASS A FIRES ORDINARY COMBUSTIBLE MATERIALS SUCH AS WOOD, PAPER, TEXTILES, AND SO FORTH. REQUIRES...COOLING-QUENCHING	**FOAM** SOLUTION OF ALUMINUM SULPHATE AND BICARBONATE OF SODA	OK FOR **AB** NOT FOR **C**	FOAM: DIRECT STREAM INTO THE BURNING LIQUID. ALLOW FOAM TO FALL LIGHTLY ON FIRE
B CLASS B FIRES FLAMMABLE LIQUIDS, GREASES, GASOLINE, OILS, PAINTS, AND SO FORTH. REQUIRES...BLANKETING OR SMOTHERING	**CARBON DIOXIDE** CARBON DIOXIDE GAS UNDER PRESSURE	NOT FOR **A** OK FOR **BC**	CARBON DIOXIDE: DIRECT DISCHARGE AS CLOSE TO FIRE AS POSSIBLE. FIRST AT EDGE OF FLAMES AND GRADUALLY FORWARD AND UPWARD
C CLASS C FIRES ELECTRICAL EQUIPMENT, MOTORS, SWITCHES, AND SO FORTH. REQUIRES...A NONCONDUCTING AGENT	**DRY CHEMICAL**	MULTI-PURPOSE TYPE: OK FOR **ABC** ORDINARY BC TYPE: NOT FOR **A**; OK FOR **BC**	DRY CHEMICAL: DIRECT STREAM AT BASE OF FLAMES, USE RAPID LEFT-TO-RIGHT MOTION TOWARD FLAMES
	SODA-ACID BICARBONATE OF SODA SOLUTION AND SULPHURIC ACID	OK FOR **A** NOT FOR **BC**	SODA-ACID: DIRECT STREAM AT BASE OF FLAME

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Additional information regarding types of extinguishers for various types of fires is provided in Table 1-1.

Eyewash Fountains

Eye injuries may occur in various ways in an automotive shop. Some of the common eye accidents are:

1. Thermal burns from excessive heat
2. Irradiation burns from excessive light such as from an arc welder
3. Chemical burns from strong liquids such as battery electrolyte
4. Foreign material in the eye
5. Penetration of the eye by a sharp object
6. A blow from a blunt object

Wearing safety glasses and observing shop safety rules will prevent most eye accidents. If a chemical gets in your eyes, it must be washed out immediately to prevent a chemical burn. An eyewash fountain is the most effective way to wash the eyes, and every shop should be equipped with some eyewash facility (Figure 1-7). Be sure you know the location of the eyewash fountain in the shop.

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Figure 1-7 Eyewash fountain.

Safety Glasses and Face Shields

The mandatory use of eye protection with safety glasses or a face shield is one of the most important safety rules in a shop. Many shop insurance policies require the use of eye protection in the shop. Some automotive technicians have been blinded in one or both eyes because they did not bother to wear safety glasses. All safety glasses must be equipped with safety glass, and they should provide some type of side protection (Figure 1-8). When selecting a pair of safety glasses, they should feel comfortable on your face. If they are uncomfortable, you may tend to take them off, leaving the eyes unprotected. A face shield should be worn when handling hazardous chemicals or when using an electric grinder or buffer (Figure 1-9).

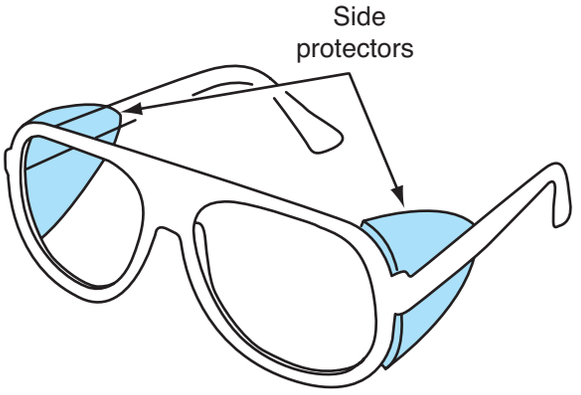

Figure 1-8 Safety glasses with side protection must be worn in the automotive shop.

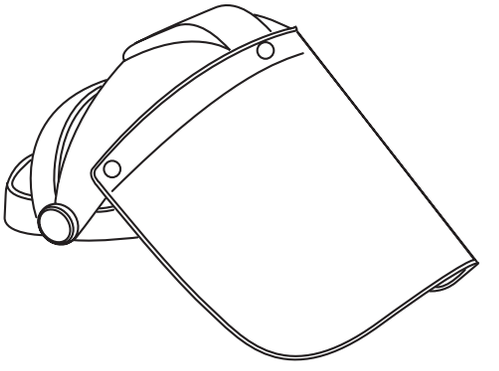

Figure 1-9 Face shield.

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Figure 1-10 First-aid kit.

First-Aid Kits

First-aid kits should be clearly identified and conveniently located (Figure 1-10). These kits contain such items as bandages and ointment required for minor cuts. All shop personnel must be familiar with the location of first-aid kits. At least one of the shop personnel should have basic first-aid training, and this person should be in charge of administering first aid and keeping first-aid kits filled.

Hazardous Waste Disposal

WARNING: To avoid personal injury when handling hazardous waste material, always wear proper protective clothing and equipment detailed in the right-to-know laws. This includes respirator equipment (Figure 1-11). All recommended procedures must be followed accurately.

Figure 1-11 Wear recommended safety clothing and equipment when hazardous materials are handled.

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Hazardous waste materials in automotive shops are chemicals or components that the shop no longer needs. These materials pose a danger to the environment and people if they are disposed of in ordinary garbage cans or sewers. However, it should be noted that no material is considered hazardous waste until the shop has finished using it and is ready to dispose of it. The Environmental Protection Agency (EPA) publishes a list of hazardous materials, which is included in the Code of Federal Regulations. Waste is considered hazardous if it is included on the EPA list of hazardous materials or if it has one or more of the following characteristics:

1. *Reactive.* Any material that reacts violently with water or other chemicals is considered hazardous. If a material releases cyanide gas when exposed to low pH acid solutions, hydrogen sulphide gas, or similar gases, it is hazardous.
2. *Corrosive.* If a material burns the skin or dissolves metals and other materials, it is considered hazardous.
3. *Toxic.* Materials are hazardous if they leach one or more of eight heavy metals in concentrations greater than 100 times primary drinking water standard.
4. *Ignitable.* A liquid is hazardous if it has a flash point below 140°F (60°C), and a solid is hazardous if it ignites spontaneously.

WARNING: Hazardous waste disposal laws include serious penalties for anyone responsible for breaking these laws.

Federal and state laws control the disposal of hazardous waste materials. Every shop employee must be familiar with these laws. Hazardous waste disposal laws include the Resource Conservation and Recovery Act (RCRA). This law basically states that hazardous material users are responsible for hazardous materials from the time they become a waste until the proper waste disposal is completed. Many automotive shops hire an independent hazardous waste hauler to dispose of hazardous waste material (Figure 1-12). The shop owner or manager should have a written contract with the hazardous waste hauler. Rather than have hazardous waste material hauled to an approved hazardous waste disposal site, a shop may choose to recycle the material in the shop. Therefore, the user must store hazardous waste material properly and safely and be responsible for the transportation of this material until it arrives at an approved hazardous waste disposal site and is processed according to the law.

The Resource Conservation and Recovery Act (RCRA) states that hazardous material users are responsible for hazardous materials from the time they become a waste until the proper waste disposal is completed.

Figure 1-12 Hazardous waste hauler.

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The RCRA controls the following types of automotive waste:

1. Paint and body repair products waste
2. Solvents for parts and equipment cleaning
3. Batteries and battery acid
4. Mild acids used for metal cleaning and preparation
5. Waste oil and engine coolants or antifreeze
6. Air-conditioning refrigerants
7. Engine oil filters

Never, under any circumstances, use the following methods to dispose of hazardous waste material:

1. Pour hazardous wastes on weeds to kill them
2. Pour hazardous wastes on gravel streets to prevent dust
3. Throw hazardous wastes in a dumpster
4. Dispose of hazardous wastes anywhere but an approved disposal site
5. Pour hazardous wastes down sewers, toilets, sinks, or floor drains

The right-to-know laws state that employees have a right to know when the materials they use at work are hazardous. The right-to-know laws started with the Hazard Communication Standard published by OSHA in 1983. This document was originally intended for chemical companies and manufacturers that required employees to handle hazardous materials in their work situation. At the present time, most states have established their own right-to-know laws. Meanwhile, the federal courts have decided to apply these laws to all companies, including automotive service shops. Under the right-to-know laws, employers have three responsibilities regarding the handling of hazardous materials by their employees.

Material safety data sheets (MSDS) provide extensive information about hazardous materials.

First, all employees must be trained about the types of hazardous materials they will encounter in the workplace. The employees must be informed about their rights under legislation regarding the handling of hazardous materials. All hazardous materials must be properly labeled, and information about each hazardous material must be posted on material safety data sheets (MSDS), which are available from the manufacturer (Figure 1-13). In Canada, MSDS sheets are called workplace hazardous materials information systems (WHMIS).

Employers have a responsibility to place MSDS sheets where they are easily accessible to all employees. The MSDS sheets provide extensive information about the hazardous material such as:

1. Chemical name
2. Physical characteristics
3. Protective equipment required for handling
4. Explosion and fire hazards
5. Other incompatible materials
6. Health hazards such as signs and symptoms of exposure, medical conditions aggravated by exposure, and emergency and first-aid procedures
7. Safe handling precautions
8. Spill and leak procedures

Secondly, the employer has a responsibility to make sure that all hazardous materials are properly labeled. The label information must include health, fire, and reactivity hazards posed by the material and the protective equipment necessary to handle the material. The manufacturer

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HEXANE
==========
MSDS Safety Information
==========
Ingredients
==========
Name: HEXANE (N_HEXANE)
% Wt: >97
OSHA PEL: 500 PPM
ACGIH TLV: 50 PPM
EPA Rpt Qty: 1 LB
DOT Rpt Qty: 1 LB
==========
Health Hazards Data
==========
LD50 LC50 Mixture: LD50:(ORAL,RAT) 28.7 KG/MG
Route Of Entry Inds _ Inhalation: YES
Skin: YES
Ingestion: YES
Carcinogenicity Inds _ NTP: NO
IARC: NO
OSHA: NO
Effects of Exposure: ACUTE:INHALATION AND INGESTION ARE HARMFUL AND MAY BE FATAL. INHALATION AND INGESTION MAY CAUSE HEADACHE, NAUSEA, VOMITING, DIZZINESS, IRRITATION OF RESPIRATORY TRACT, GASTROINTESTINAL IRRITATION AND UNCONSCIOUSNESS. CONTACT W/SKIN AND EYES MAY CAUSE IRRITATION. PROLONGED SKIN MAY RESULT IN DERMATITIS (EFTS OF OVEREXP)
Signs And Symptions Of Overexposure: HLTH HAZ:CHRONIC:MAY INCLUDE CENTRAL NERVOUS SYSTEM DEPRESSION.
Medical Cond Aggravated By Exposure: NONE IDENTIFIED.
First Aid: CALL A PHYSICIAN. INGEST:DO NOT INDUCE VOMITING. INHAL:REMOVE TO FRESH AIR. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN. EYES:IMMED FLUSH W/PLENTY OF WATER FOR AT LEAST 15 MINS. SKIN:IMMED FLUSH W/P LENTY OF WATER FOR AT LEAST 15 MINS WHILE REMOVING CONTAMD CLTHG & SHOES. WASH CLOTHING BEFORE REUSE.
==========
Handling and Disposal
==========
Spill Release Procedures: WEAR NIOSH/MSHA SCBA & FULL PROT CLTHG. SHUT OFF IGNIT SOURCES:NO FLAMES, SMKNG/FLAMES IN AREA. STOP LEAK IF YOU CAN DO SO W/OUT HARM. USE WATER SPRAY TO REDUCE VAPS. TAKE UP W/SAND OR OTHER NON_COMBUST MATL & PLACE INTO CNTNR FOR LATER (SU PDAT)
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Waste Disposal Methods: DISPOSE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS. EPA HAZARDOUS WASTE NUMBER:D001 (IGNITABLE WASTE).
Handling And Storage Precautions: BOND AND GROUND CONTAINERS WHEN TRANSFERRING LIQUID. KEEP CONTAINER TIGHTLY CLOSED.
Other Precautions: USE GENERAL OR LOCAL EXHAUST VENTILATION TO MEET TLVREQUIREMENTS. STORAGE COLOR CODE RED (FLAMMABLE).
==========
Fire and Explosion Hazard Information
==========
Flash Point Method: CC
Flash Point Text: _9F,_23C
Lower Limits: 1.2%
Upper Limits: 77.7%
Extinguishing Media: USE ALCOHOL FOAM, DRY CHEMICAL OR CARBON DIOXIDE. (WATER MAY BE INEFFECTIVE).
Fire Fighting Procedures: USE NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE EQUIPMENT (FP N).
Unusual Fire/Explosion Hazard: VAP MAY FORM ALONG SURFS TO DIST IGNIT SOURCES & FLASH BACK. CONT W/STRONG OXIDIZERS MAY CAUSE FIRE. TOX GASES PRDCED MAY INCL:CARBON MONOXIDE, CARBON DIOXIDE.
==========

Figure 1-13 Material safety data sheets (MSDS) inform employees about hazardous materials.

must supply all warning and precautionary information about hazardous materials, and this information must be read and understood by the employee before handling the material.

Thirdly, employers are responsible for maintaining permanent files regarding hazardous materials. These files must include information on hazardous materials in the shop, proof of employee training programs, and information about accidents such as spills or leaks of hazardous materials. Employers' files must also include proof that employees' requests for hazardous material information such as MSDS sheets have been met. A general right-to-know compliance procedure manual must be maintained by employers.

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Personal Safety

Personal safety is the responsibility of each technician in the shop. Always follow these safety practices:

1. Always use the correct tool for the job. If the wrong tool is used, it may slip and cause hand injury.
2. Follow the car manufacturer's recommended service procedures.
3. Always wear eye protection such as safety glasses or a face shield (Figure 1-14).
4. Wear protective gloves when cleaning parts in hot or cold tanks and when handling hot parts such as exhaust manifolds.
5. Do not smoke when working on a vehicle. A spark from a cigarette or lighter may ignite flammable materials in the work area.
6. When working on a running engine, keep hands and tools away from rotating parts. Remember that electric-drive fans may start turning at any time.
7. Do not wear loose clothing, and keep long hair tied behind your head. Loose clothing or long hair is easily entangled in rotating parts.
8. Wear safety shoes or boots.
9. Do not wear watches, jewelry, or rings when working on a vehicle. Severe burns occur when jewelry makes contact between an electric terminal and ground.
10. Always place a shop exhaust hose on the vehicle tailpipe if the engine is running, and be sure the exhaust fan is running. Carbon monoxide in the vehicle exhaust is harmful or fatal to the human body.
11. Be sure that the shop has adequate ventilation.
12. Make sure the work area has adequate lighting.
13. Use trouble lights with steel or plastic cages around the bulb. If an unprotected bulb breaks, it may ignite flammable materials in the area.
14. When servicing a vehicle, always apply the parking brake and place the transmission in park with an automatic transmission or neutral with a manual transmission.
15. Avoid working on a vehicle parked on an incline.
16. Never work under a vehicle unless the vehicle chassis is supported securely on safety stands.

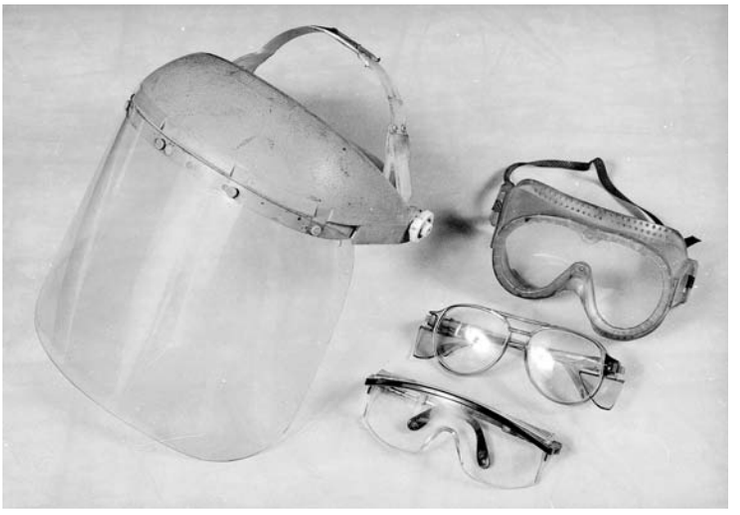

Figure 1-14 Safety glasses.

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17. When one end of a vehicle is raised, place wheel chocks on both sides of the wheels remaining on the floor.
18. Be sure that you know the location of shop first-aid kits and eyewash fountains.
19. Familiarize yourself with the location of all shop fire extinguishers.
20. Do not use any type of open flame heater to heat the work area.
21. Collect oil, fuel, brake fluid, and other liquids in the proper safety containers.
22. Use only approved cleaning fluids and equipment. Do not use gasoline to clean parts.
23. Obey all state and federal safety, fire, and hazardous material regulations.
24. Always operate equipment according to the equipment manufacturer's recommended procedure.
25. Do not operate equipment unless you are familiar with the correct operating procedure.
26. Do not leave running equipment unattended.
27. Do not use electrical equipment, including trouble lights, with frayed cords.
28. Be sure the safety shields are in place on rotating equipment.
29. Before operating electric equipment, be sure the power cord has a ground connection.
30. When working in an area where extreme noise levels are encountered, wear ear plugs or covers.

Lifting and Carrying

Many automotive service jobs require heavy lifting. You should know your maximum weight lifting ability. Do not attempt to lift more than this weight. If a heavy part exceeds your weight lifting ability, have a co-worker help with the lifting job. Follow these steps when lifting or carrying an object:

1. If the object is to be carried, be sure your path is free from loose parts or tools.
2. Position your feet close to the object and position your back reasonably straight for proper balance.
3. Your back and elbows should be kept as straight as possible. Continue to bend your knees until your hands reach the best lifting location on the object to be lifted.
4. Be certain the container is in good condition. If a container falls apart during the lifting operation, parts may drop out of the container and result in foot injury or part damage.
5. Maintain a firm grip on the object, and do not attempt to change your grip while lifting is in progress.
6. Straighten your legs to lift the object, and keep the object close to your body. Use leg muscles rather than back muscles.
7. If you have to change the direction of travel, turn your whole body instead of twisting it.
8. Do not bend forward to place an object on a workbench or table. Position the object on the front surface of the workbench and slide it back. Do not pinch your fingers under the object while setting it on the front of the bench.
9. If the object must be placed on the floor or a low surface, bend your legs to lower the object. Do not bend your back forward because this movement strains back muscles.
10. When a heavy object must be placed on the floor, locate suitable blocks under the object to prevent jamming your fingers under the object.

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Hand Tool Safety

Many shop accidents are caused by improper use and care of hand tools. These hand tool safety steps must be followed:

1. Maintain tools in good condition and keep them clean. Worn tools may slip and cause hand injury. If a hammer is used with a loose head, the head may fly off and cause personal injury or vehicle damage. Your hand may slip off a greasy tool, and this action may cause some part of your body to hit the vehicle. For example, your head may hit the vehicle hood.
2. Using the wrong tool for the job may cause damage to the tool, fastener, or your hand if the tool slips. If you use a screwdriver for a chisel or pry bar, the blade may shatter, causing serious personal injury.
3. Use sharp pointed tools with caution. Always check your pockets before sitting on the vehicle seat. A screwdriver, punch, or chisel in the back pocket may put an expensive tear in the upholstery. Do not lean over fenders with sharp tools in your pockets.
4. Tool tips that are intended to be sharp should be kept in a sharp condition. Sharp tools, such as chisels, will do the job faster with less effort.

Power Tool Safety

Power tools use electricity, shop air, or hydraulic pressure as a power source. Careless operation of power tools may cause personal injury and vehicle damage. Follow these steps for safe power tool operation:

1. Do not operate power tools with frayed power cords.
2. Be sure the power tool cord has a proper ground connection.
3. Do not stand on a wet floor while operating an electric power tool.
4. Always unplug an electric power tool before servicing the tool.
5. Do not leave a power tool running and unattended.
6. When using a power tool on small parts, do not hold the part in your hand. The part must be secured in a bench vise or with locking pliers.
7. Do not use a power tool on a job where the maximum capacity of the tool is exceeded.
8. Be sure that all power tools are in good condition, and always operate these tools according to the tool manufacturer's recommended procedure.
9. Make sure all protective shields and guards are in position.
10. Maintain proper body balance while using a power tool.
11. Always wear safety glasses or a face shield.
12. Wear ear protection.
13. Follow the equipment manufacturer's recommended maintenance schedule for all shop equipment.
14. Never operate a power tool unless you are familiar with the tool manufacturer's recommended operating procedure. Serious accidents occur from improper operating procedures.
15. Always make sure that the wheels are in good condition and are securely attached on the electric grinder.
16. Keep fingers and clothing away from grinding and buffing wheels. When grinding or buffing a small part, it should be held with a pair of locking pliers.
17. Always make sure the sanding or buffing disc is securely attached to the sander pad.

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18. Special heavy-duty sockets must be used on impact wrenches. If ordinary sockets are used on an impact wrench, they may break and cause serious personal injury.
19. Never operate an air chisel unless the tool is securely connected to the chisel with the proper retaining device.
20. Never direct a blast of air from an air gun against any part of your body. If air penetrates the skin and enters the bloodstream, it may cause very serious health problems and even death.

Compressed Air Equipment Safety

The shop air supply contains high-pressure air in the shop compressor and air lines. Serious injury or property damage may result from careless operation of compressed air equipment. Follow these steps to improve safety when using compressed air equipment:

1. Wear safety glasses or a face shield for all shop tasks, including those tasks involving the use of compressed air equipment.
2. Wear ear protection when using compressed air equipment.
3. Always maintain air hoses and fittings in good condition. If an end suddenly blows off an air hose, the hose will whip around, and this may cause personal injury.
4. Do not direct compressed air against the skin. This air may penetrate the skin, particularly through small cuts or scratches. If air penetrates the skin and enters the bloodstream, it can be fatal or cause serious health complications. Use only air gun nozzles approved by OSHA.
5. Do not use an air gun to blow off clothing or hair.
6. Do not clean the workbench or floor with compressed air. This action may blow very small parts against your skin or into your eye. Small parts blown by compressed air may cause vehicle damage. For example, if the car in the next stall has the air cleaner removed, a small part may go into the carburetor or throttle body. When the engine is started, this part will likely be pulled into the cylinder by engine vacuum, and the part will penetrate through the top of a piston.
7. Never spin bearings with compressed air because the bearing will rotate at extremely high speed. Under this condition, the bearing may be damaged or disintegrate, causing personal injury.
8. All pneumatic tools must be operated according to the tool manufacturer's recommended operating procedure.
9. Follow the equipment manufacturer's recommended maintenance schedule for all compressed air equipment.

Hydraulic Pressing and Lifting Equipment

Hydraulic Press

WARNING: When operating a hydraulic press, always be sure that the components being pressed are properly supported on the press bed with steel supports. Improperly supported components may suddenly move or fall, resulting in personal injury.

WARNING: When using a hydraulic press, never operate the pump handle until the pressure gauge exceeds the maximum pressure rating of the press. If this pressure is exceeded, some part of the press may suddenly break and cause severe personal injury.

When two components have a tight precision fit between them, a hydraulic press is used to separate these components or press them together. The hydraulic press rests on the shop floor, and an

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Figure 1-15 Hydraulic press.

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adjustable steel beam bed is retained to the lower press frame with heavy steel pins. A hydraulic cylinder and ram is mounted on the top part of the press with the ram facing downward toward the press bed (Figure 1-15). The component being pressed is placed on the press bed with appropriate steel supports. A hand-operated hydraulic pump is mounted on the side of the press. When the handle is pumped, hydraulic fluid is forced into the cylinder, and the ram is extended against the component on the press bed to complete the pressing operation. A pressure gauge on the press indicates the pressure applied from the hand pump to the cylinder. The press frame is designed for a certain maximum pressure, and this pressure must not be exceeded during hand pump operation.

Floor Jack

CAUTION: The maximum lifting capacity of the floor jack is usually written on a jack decal. Never lift a vehicle that exceeds the jack lifting capacity. This action may cause the jack to break or collapse, resulting in vehicle damage or personal injury.

A floor jack is a portable unit mounted on wheels. The lifting pad on the jack is placed under the chassis of the vehicle, and the jack handle is operated with a pumping action (Figure 1-16). This jack handle operation forces fluid into a hydraulic cylinder in the jack, and this cylinder extends to force the jack lift pad upward and lift the vehicle. Always be sure that the lift pad is positioned securely under one of the car manufacturer's recommended lift points. To release the hydraulic pressure and lower the vehicle, the handle or release lever must be turned slowly. Do not leave the jack handle where someone can trip over it.

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Figure 1-16 Hydraulic floor jack.

Lift

WARNING: Always be sure that the lift arms are securely positioned under the car manufacturer's recommended lift points before raising a vehicle. These lift points are shown in the service manual. Using improper lift points may cause the vehicle to slip off the lift, resulting in vehicle damage or personal injury.

CAUTION: The maximum capacity of the vehicle lift is placed on an identification plate. Never lift a vehicle that is heavier than the maximum capacity of the lift.

A lift may be referred to as a hoist.

An engine lift may be called a crane or a cherry picker.

A lift is used to raise a vehicle so the technician can work under the vehicle. The lift arms must be placed under the car manufacturer's recommended lift points prior to raising a vehicle. Twin posts are used on some lifts, whereas other lifts have a single post (Figure 1-17). Some lifts have an electric motor that drives a hydraulic pump to create fluid pressure and force the lift upward. Other lifts use air pressure from the shop air supply to force the lift upward. If shop air pressure is used for this purpose, the air pressure is applied to fluid in the lift cylinder. A control lever or switch is placed near the lift. The control lever supplies shop air pressure to the lift cylinder, and the switch turns on the lift pump motor. Always be sure that the safety lock is engaged after the lift is raised. When the safety lock is released, a release lever is operated slowly to lower the vehicle.

Figure 1-17 Lifts are used to raise a vehicle.

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Lift Safety

WARNING: Do not raise a vehicle on a lift if the vehicle weight exceeds the maximum capacity of the lift. This action may result in lift damage or sudden lowering of the lift, which may result in personal injury.

WARNING: When a vehicle is raised on a lift, the vehicle must be raised high enough to allow engagement of the lift locking mechanism. If the locking mechanism is not engaged, the lift may drop suddenly, resulting in personal injury.

Special precautions and procedures must be followed when a vehicle is raised on a lift. Follow these steps for lift safety:

1. Always be sure the lift is completely lowered before driving a vehicle on or off the lift.
2. Do not hit or run over lift arms and adapters when driving a vehicle on or off the lift. Have a co-worker guide you when driving a vehicle onto the lift. Do not stand in front of a lift with the car coming towards you.
3. Be sure the lift pads on the lift are contacting the car manufacturer's recommended lift points shown in the service manual. If the proper lift points are not used, components under the vehicle such as brake lines or body parts may be damaged. Failure to use the recommended lift points may cause the vehicle to slip off the lift, resulting in severe vehicle damage and personal injury.
4. Before a vehicle is raised or lowered, close the doors, hood, and trunk lid.
5. When a vehicle is lifted a short distance off the floor, stop the lift and check the contact between the hoist lift pads and the vehicle to be sure the lift pads are still on the recommended lift points.
6. When a vehicle is raised on a lift, be sure the safety mechanism is in place to prevent the lift from accidentally dropping.
7. Before lowering a vehicle on a lift, always make sure there are no objects, tools, or people under the vehicle.
8. Do not rock a vehicle on a lift during a service job.
9. When a vehicle is raised on a lift, removal of some heavy components may cause vehicle imbalance on the lift. Since front-wheel-drive cars have the engine and transaxle located at the front of the vehicle, these cars have most of their weight on the front end. Removing a heavy rear-end component on these cars may cause the back end of the car to rise off the lift. If this action is allowed to happen, the vehicle could fall off the lift!
10. Do not raise a vehicle on a lift with people in the vehicle.
11. When raising pickup trucks and vans on a lift, remember these vehicles are higher than a passenger car. Be sure there is adequate clearance between the top of the vehicle and the shop ceiling or components under the ceiling.
12. *Do not raise a four-wheel-drive vehicle with a frame contact lift because this may damage axle joints.*
13. Do not operate a front-wheel-drive vehicle that is raised on a frame contact lift. This action may damage the front drive axles.

Engine Lift

WARNING: An engine lift has a maximum lifting capacity that is usually indicated on a decal. Never lift anything heavier than the maximum capacity of the lift. This action may result in lift damage or personal injury.

An engine lift is used to remove and replace automotive engines. A long, pivoted arm is mounted on the top of the engine lift (Figure 1-18). When the lift handle is pumped, hydraulic fluid is forced into a cylinder under the lift arm. This action extends the cylinder ram and forces the arm

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Figure 1-18 Engine lift.

upward to lift the engine. A lifting chain is attached to the lift arm, and this chain is bolted securely to the engine. Always be sure that these retaining bolts are strong enough to support the engine weight.

Hydraulic Jack and Jack Stand Safety

CAUTION: Always make sure the jack stand weight capacity rating exceeds the vehicle weight that is lowered onto the stands.

WARNING: Never lift a vehicle with a floor jack if the weight of the vehicle exceeds the rated capacity of the jack. This action may cause the jack to drop suddenly, resulting in personal injury or vehicle damage.

Accidents involving the use of floor jacks and jack stands may be avoided if these safety precautions are followed:

1. Never work under a vehicle unless jack stands are placed securely under the vehicle chassis and the vehicle is resting on these stands (Figure 1-19).

Figure 1-19 Jack stands.

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2. Before lifting a vehicle with a floor jack, be sure that the jack lift pad is positioned securely under a recommended lift point on the vehicle. Lifting the front end of a vehicle with the jack placed under a radiator support may cause severe damage to the radiator and support.
3. Position the jack stands under a strong chassis member such as the frame or axle housing. The jack stands must contact the vehicle manufacturer's recommended lift points.
4. Since the floor jack is on wheels, the vehicle and jack tend to move as the vehicle is lowered from a floor jack onto jack stands. Always be sure the jack stands remain under the chassis member during this operation, and be sure the jack stands do not tip. All of the jack stand legs must remain in contact with the shop floor.
5. When the vehicle is lowered from the floor jack onto jack stands, remove the floor jack from under the vehicle. Never leave a jack handle sticking out from under a vehicle. Someone may trip over the handle and injure themselves.

Cleaning Equipment Safety and Environmental Considerations

WARNING: Some parts cleaners contain caustic solutions. To avoid personal injury, always wear protective gloves and a face shield when using this equipment.

All technicians are required to clean parts during their normal work routines. Face shields and protective gloves must be worn while operating cleaning equipment. In most states, environmental regulations require that the runoff from steam cleaning must be contained in the steam cleaning system. This runoff cannot be dumped into the sewer system. Since it is expensive to contain this runoff in the steam cleaner system, the popularity of steam cleaning has decreased. The solution in hot and cold cleaning tanks may be caustic, and contact between this solution and skin or eyes must be avoided. Parts cleaning often creates a slippery floor, and care must be taken when walking in the parts cleaning area. The floor in this area should be cleaned frequently. When the caustic cleaning solution in hot or cold cleaning tanks is replaced, environmental regulations require that the old solution be handled as hazardous waste. Use caution when placing aluminum or aluminum alloy parts in a cleaning solution. Some cleaning solutions will damage these components. Always follow the cleaning equipment manufacturer's recommendations.

Parts Washers with Electromechanical Agitation

Some parts washers provide electromechanical agitation of the parts to provide improved cleaning action (Figure 1-20). These parts washers may be heated with gas or electricity, and various water-based hot tank cleaning solutions are available depending on the type of metals being cleaned. For example, Kleer-Flo Greasoff number 1 powdered detergent is available for cleaning iron and steel. Nonheated electromechanical parts washers are also available. These washers use cold cleaning solutions such as Kleer-Flo Degreasol formulas.

Many cleaning solutions, such as Kleer-Flo Degreasol 99R, contain no ingredients listed as hazardous by the Environmental Protection Agency's RCRA Act. This cleaning solution is a blend of sulphur-free hydrocarbons, wetting agents, and detergents. Degreasol 99R does not contain aromatic or chlorinated solvents, and it conforms to California's Rule 66 for clean air. Always use the cleaning solution recommended by the equipment manufacturer.

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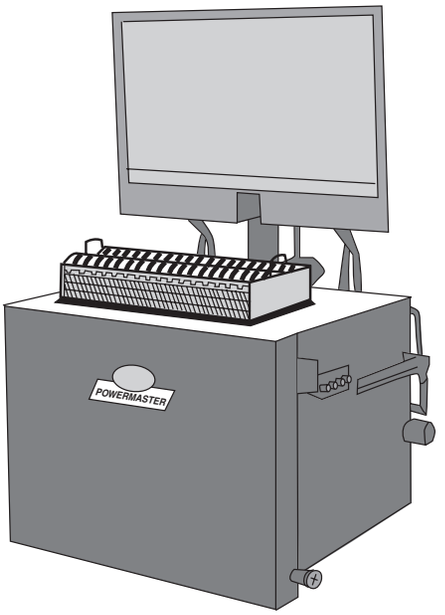

Figure 1-20 Parts washer with electromechanical agitator.

Cold Parts Washer with Agitated Immersion Tank

Some parts washers have an agitated immersion chamber under the shelves, which provides thorough parts cleaning. Folding workshelves provide a large upper cleaning area with a constant flow of solution from the dispensing hose (Figure 1-21). This cold parts washer operates on Degreasol 99R cleaning solution.

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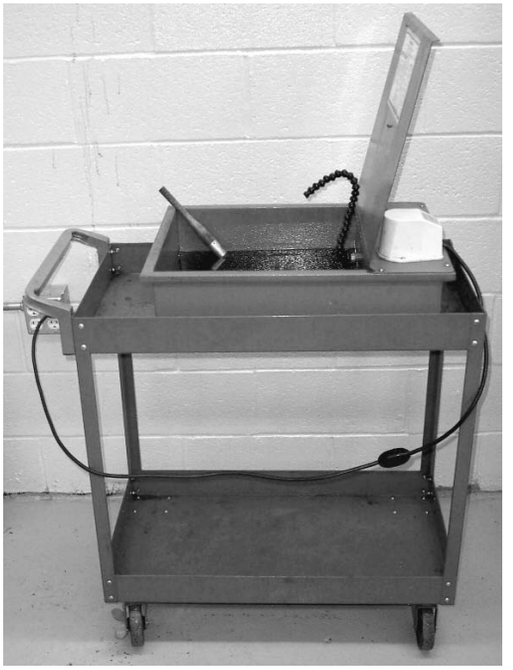

Figure 1-21 Cold parts washer with agitated immersion tank.

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Figure 1-22 Aqueous parts cleaning tank.

Aqueous Parts Cleaning Tank

The aqueous parts cleaning tank uses a water-based environmentally friendly cleaning solution, such as Greasoff 2, rather than traditional solvents. The immersion tank is heated and agitated for effective parts cleaning (Figure 1-22). A sparger bar pumps a constant flow of cleaning solution across the surface to push floating oils away, and an integral skimmer removes these oils. This action prevents floating surface oils from redepositing on cleaned parts.

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Safety Training Exercises

After the equipment operation and safety practices are explained by your instructor, complete these safety training exercises to demonstrate your understanding of equipment operation and safety procedures:

1. Find the lift points on a specific vehicle in the vehicle manufacturer's service manual. Under the supervision of your instructor, position this vehicle properly on a lift, then use the proper lift operating procedures to raise and lower the vehicle on the lift.
2. Find the lift points on a specific vehicle in the vehicle manufacturer's service manual. Under the supervision of your instructor, raise the front and rear suspension of this vehicle with a floor jack and lower the vehicle onto jack stands. Raise the vehicle with a floor jack, and remove the jack stands, and lower the vehicle.
3. Find the lift points on a specific vehicle in the vehicle manufacturer's service manual. Under the supervision of your instructor, position this vehicle properly on a lift and raise the vehicle. Follow proper service and safety procedures to remove and replace all four wheels. Remove two wheels with an electric impact wrench and the other two wheels with an air impact wrench.
4. Draw a layout diagram of your automotive shop or shops, indicating the major service areas and service equipment, and clearly identify the location of all safety equipment.

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CUSTOMER CARE: Some automotive service centers have a policy of performing some minor service as an indication of their appreciation to the customer. This service may include cleaning all the windows and/or vacuuming the floors before the car is returned to the customer.

Although this service involves more labor costs for the shop, it may actually improve profits over a period of time. When customers find their windows cleaned and/or the floors vacuumed, it impresses them with the quality of work you do and the fact that you care about their vehicle. They will likely return for service and tell their friends about the quality of service your shop performs.

Guidelines for Use of Tools, Safety Practices, and the Use of Test Equipment

1. Two systems of measurement in common use are the United States customary (USC) and international system (SI).
2. The SI system may be called the metric system.
3. In the metric system, the units can be divided or multiplied by 10.
4. Personal safety is the responsibility of everyone in the shop.
5. When lifting heavy objects, always bend your knees rather than your back.
6. Many shop accidents are caused by the improper use of hand tools.
7. Never operate any type of equipment unless you are familiar with the proper operating procedure.
8. Never exceed the rated capacity of a hydraulic press, hydraulic jack, vehicle lift, or jack stands.
9. When raising a vehicle with a lift or floor jack, always be sure the lifting equipment is contacting the vehicle on the manufacturer's recommended lift points.
10. After a vehicle is raised on a lift, be sure the lift locking mechanism is in place.
11. Never operate electric equipment with a frayed cord or without a ground wire.
12. Never direct a blast of compressed air against human flesh.
13. Always wear eye protection and protective gloves when cleaning parts in any type of cleaning solution.
14. Electronic fuel injection (EFI) systems must be depressurized before connecting a fuel gauge or disconnecting fuel system components.
15. On a port fuel injection (PFI) system, the pressure gauge is connected to the Schrader valve on the fuel rail.
16. On throttle body injection (TBI) or carburetor systems, the fuel pressure gauge must be connected in series at the fuel inlet line.
17. The injector balance tester is a timing device that opens each injector for a specific length of time.
18. During an injector balance test, the fuel system pressure drop is recorded when each injector is opened for a specific length of time.
19. Injectors are cleaned with a solution of unleaded gasoline and injector cleaner in a pressurized container connected to the Schrader valve on the fuel rail.
20. During the injector cleaning procedure, the return fuel line must be blocked, and the electric fuel pump must be disabled.
21. Conventional 12-volt or self-powered test lights should not be used to test computer circuits. High-impedance test lights should be used for this purpose.
22. Test lights of any type must not be used to diagnose air bag circuits. Only the vehicle manufacturer's recommended tools should be used on these systems.

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23. Volt-ampere testers are commonly used to perform battery load tests, starter current draw tests, alternator output tests, and alternator normal system voltage tests.
24. Multimeters read AC volts, DC volts, milliamperes, amperes, and ohms on various scales.
25. Digital multimeters have higher impedance than analog multimeters.
26. Only high-impedance digital multimeters should be used to test computer system components such as oxygen (O_2) sensors.
27. Tach-dwellmeters read engine rpm and ignition dwell.
28. A piece of reflective tape attached to a rotating component, such as the crankshaft pulley, provides a signal for a photoelectric tachometer.
29. The probe on a magnetic probe-type digital tachometer is installed in the magnetic timing receptacle above the crankshaft pulley.
30. The control knob on an advance-type timing light may be used to check spark advance.
31. When a magnetic probe-type digital timing meter is used, the offset on the tester must be adjusted for the engine being tested.
32. Many ignition module testers check the ignition module and primary ignition circuit voltage and current under various engine operating conditions.
33. An oscilloscope contains a cathode ray tube (CRT), which provides a voltage trace of the ignition system voltage much like a very fast reacting voltmeter.
34. Scan testers retrieve fault codes from the computer memory and perform many other diagnostic functions.
35. The scan tester must be programmed for the vehicle make, model year, and type of engine.
36. Since most scan testers have the capability to test various computer systems on the vehicle, the tester must be programmed for the computer system being tested.
37. The scan tester must be connected to the appropriate diagnostic connector on the vehicle.
38. A two-gas emissions analyzer reads carbon monoxide (CO) and hydrocarbon (HC) emission levels.
39. A four-gas emissions analyzer reads the same emission levels as a two-gas analyzer, plus oxygen (O_2) and carbon dioxide (CO_2). The latter two emissions are not affected by the catalytic converter.
40. Emissions analyzers require a 15-minute warm-up and calibration period when they are turned on.
41. An engine analyzer contains a combination of many different automotive testers.

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Shop Layout

There are many different types of shops in the automotive service industry, including new car dealers, independent repair shops, specialty shops, service stations, and fleet shops.

WARNING: Always know the location of all safety equipment in the shop and be familiar with the operation of this equipment.

The **shop layout** in any shop is important to maintaining shop efficiency and safety. Shop layout includes bays for various types of repairs, space for equipment storage, and office locations. Safety equipment such as fire extinguishers, first-aid kits, and eyewash fountains must be in easily accessible locations. The location of each piece of safety equipment must be clearly marked. Areas such as the parts department and the parts cleaning area must be located so they are easily accessible from all areas of the shop. The service manager's office should also be centrally located. All shop personnel should familiarize themselves with the shop layout, especially

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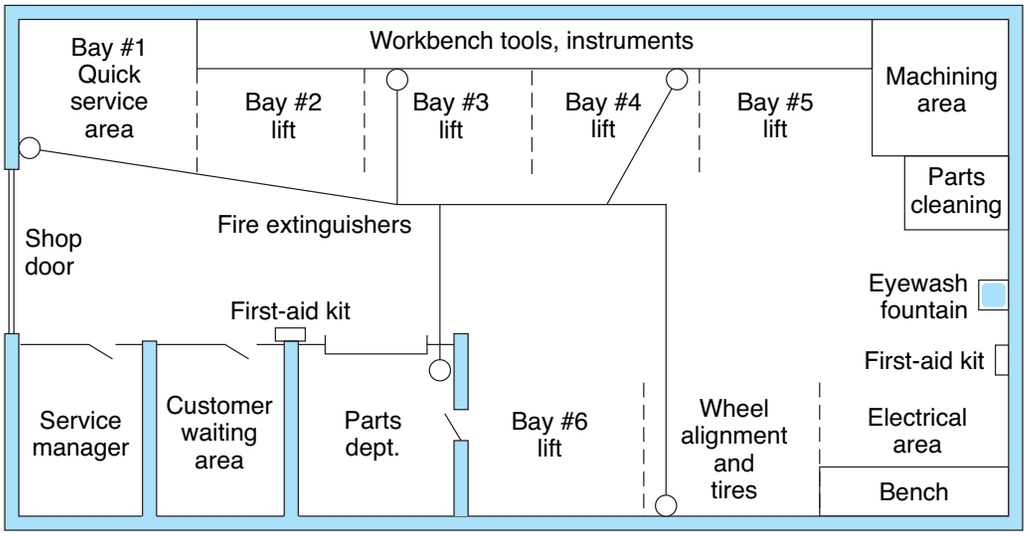

Figure 1-23 Typical shop layout.

the location of safety equipment. If you know the exact fire extinguisher locations, you may get an extinguisher into operation a few seconds faster. These few seconds could make the difference between a fire that is quickly extinguished and one that gets out of control, causing extensive damage and personal injury! Most shops have specific bays for certain types of work, such as electrical repair, wheel alignment and tires, and machining (Figure 1-23).

The tools and equipment required for a certain type of work are stored in that specific bay. For example, the equipment for electrical and electronic service work is stored in the bay allotted to that type of repair. When certain bays are allotted to specific types of repair work, unnecessary equipment movement is eliminated. Each technician has his or her own tools on a portable roll cabinet which is moved to the vehicle being repaired. Special tools are provided by the shop, and these tools may be located on tool boards attached to the wall. Other shops may have a tool room where special tools are located. Adequate workbench space must be provided in those bays where bench work is required.

Shop Rules

CAUTION: Shop rules, vehicle operation in the shop, and shop housekeeping are serious business. Each year a significant number of technicians are injured and vehicles damaged by disregarding shop rules, careless vehicle operation, and sloppy housekeeping.

The application of some basic shop rules helps to prevent serious, expensive accidents. Failure to comply with shop rules may cause personal injury or expensive damage to vehicles and shop facilities. It is the responsibility of the employer and all shop employees to make sure that shop rules are understood and followed until these rules become automatic habits. The following basic shop rules should be followed:

1. Always wear safety glasses and other protective equipment that is required by a service procedure. For example, a special parts washer must be used to avoid breathing asbestos dust into the lungs. *Asbestos dust is a known cause of lung cancer.* This dust is encountered in manual transmission clutch facings and brake linings.
2. Tie long hair securely behind the head, and do not wear loose or torn clothing.

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Carbon monoxide is a poisonous gas and, when breathed into the lungs, it may cause headaches, nausea, ringing in the ears, tiredness, and heart flutter. In strong concentrations, it causes death.

3. Do not wear rings, watches, or loose hanging jewelry. If jewelry such as a ring, metal watch band, or chain makes contact between an electrical terminal and ground, the jewelry becomes extremely hot, resulting in severe burns.
4. Set the parking brake when working on a vehicle. If the vehicle has an automatic transmission, place the gear selector in park unless a service procedure requires another selector position. When the vehicle is equipped with a manual transmission, position the gear selector in neutral with the engine running or reverse with the engine stopped.
5. Always connect a shop exhaust hose to the vehicle tailpipe and be sure the shop exhaust fan is running. If it is absolutely necessary to operate a vehicle without a shop exhaust pipe connected to the tailpipe, open the large shop door to provide adequate ventilation. Carbon monoxide in the vehicle exhaust may cause severe headaches and other medical problems. High concentrations of carbon monoxide may result in death!
6. Keep hands, clothing, and wrenches away from rotating parts such as cooling fans. Remember that electric-drive fans may start turning at any time, even with the ignition off.
7. Always leave the ignition switch off unless a service procedure requires another switch position.
8. Do not smoke in the shop. If the shop has designated smoking areas, smoke only in these areas.
9. Store oily rags and other discarded combustibles in regulation, covered metal garbage containers.
10. Always use a wrench or socket that fits properly on the bolt. Do not substitute metric for English wrenches or vice versa.
11. Keep tools in good condition. For example, do not use a punch or chisel with a mushroomed end. When struck with a hammer, a piece of the mushroomed metal could break off, resulting in severe eye or other injury.
12. Do not leave power tools running and unattended.
13. Serious burns may be prevented by avoiding contact with hot metal components such as exhaust manifolds, other exhaust system components, radiators, and some air-conditioning hoses.
14. When lubricant such as engine oil is drained, always use caution because the oil could be hot enough to cause burns.
15. Before getting under a vehicle, be sure the vehicle is placed securely on safety stands.
16. Operate all shop equipment, including lifts, according to the equipment manufacturer's recommended procedure. Do not operate equipment unless you are familiar with the correct operating procedure.
17. Do not run or engage in horseplay in the shop.
18. Obey all state and federal fire, safety, and environmental regulations.
19. Do not stand in front of or behind vehicles.
20. Always place fender covers and a seat cover on a customer's vehicle before working on the car.
21. Inform the shop foreman of any safety dangers and suggestions for safety improvement.

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Vehicle Operation

When driving a customer's vehicle, certain precautions must be observed to prevent accidents and maintain good customer relations.

1. Before driving a vehicle, always make sure the brakes are operating and fasten the safety belt.
2. Check to be sure there are no people or objects under the car before you start the engine.
3. If the vehicle is parked on a lift, be sure the lift is fully down and the lift arms or components are not contacting the vehicle chassis.
4. Check to see if there are any objects directly in front of or behind the vehicle before driving away.
5. Always drive slowly in the shop and watch carefully for personnel and other moving vehicles.
6. Make sure the shop door is up high enough so there is plenty of clearance between the top of the vehicle and the door.
7. Watch the shop door to be certain that it is not coming down as you attempt to drive under the door.
8. If a road test is necessary, obey all traffic laws, and never drive in a reckless manner.
9. Do not squeal tires when accelerating or turning corners.

If customers observe that service personnel take good care of their cars by driving carefully and installing fender and seat covers, the service department image is greatly enhanced in their eyes. These procedures impress upon customers that shop personnel respect their cars. Conversely, if grease spots are found on the upholstery or fenders after service work is completed, customers will probably think the shop is very careless, not only in car care, but also in service work quality.

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Housekeeping

CUSTOMER CARE: When customers see that you are concerned about their vehicles and that you operate a shop with excellent housekeeping habits, they will be impressed and will likely keep returning for service.

Careful housekeeping habits prevent accidents and increase worker efficiency. Good housekeeping also helps to impress upon customers that quality work is a priority in this shop. Follow these housekeeping rules:

1. Keep aisles and walkways clear of tools, equipment, and other items.
2. Be sure all sewer covers are securely in place.
3. Keep floor surfaces free of oil, grease, water, and loose material.
4. Place proper garbage containers in convenient locations and empty them regularly.
5. Make sure that access to fire extinguishers is unobstructed at all times, and check fire extinguishers for proper charge at regular intervals.

Excellent housekeeping involves general shop cleanliness, proper shop safety equipment in good working condition, and the proper maintenance of all shop equipment and tools.

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SERVICE TIP: When you are finished with a tool, never set it on the customer's car. After using a tool, the best place for it is in your tool box or on the workbench. Many tools have been lost by leaving them on customers' vehicles.

6. Keep tools clean and in good condition.
7. When not in use, store tools in their proper location.
8. Place oily rags and other combustibles in properly covered garbage containers.
9. Make sure that rotating components on equipment and machinery have guards and that all shop equipment has regular service and adjustment schedules.
10. Maintain benches and seats in a clean condition.
11. Keep parts and materials in their proper location.
12. When not in use, store creepers in a specific location.
13. Make sure that the shop is well lighted, and keep all lights in working order.
14. Replace frayed electrical cords on lights or equipment.
15. Regularly clean walls and windows.
16. Keep stairs clean, well lighted, and free of loose material.

If these housekeeping rules are followed, the shop will be a safer place to work, and customers will be impressed with the appearance of the premises.

Air Quality

WARNING: Never run the engine in a vehicle inside the shop without an exhaust hose connected to the tailpipe.

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Vehicle exhaust contains small amounts of carbon monoxide, which is a poisonous gas. Strong concentrations of carbon monoxide may be fatal for human beings. All shop personnel are responsible for air quality in the shop.

Shop management is responsible for an adequate exhaust system to remove exhaust fumes from the maximum number of vehicles that may be running in the shop at the same time.

Technicians should never run a vehicle in the shop unless a shop exhaust hose is installed on the tailpipe of the vehicle. The exhaust fan must be switched on to remove exhaust fumes.

If shop heaters or furnaces have restricted chimneys, they release carbon monoxide emissions into the shop air. Therefore, chimneys should be checked periodically for restriction and proper ventilation.

Monitors are available to measure the level of carbon monoxide in the shop. Some of these monitors read the amount of carbon monoxide present in the shop air, and other monitors provide an audible alarm if the concentration of carbon monoxide exceeds the danger level.

Diesel exhaust contains some carbon monoxide, but particulates are also present in the exhaust from these engines. Particulates are basically small carbon particles, which can be harmful to the lungs.

The sulfuric acid solution in car batteries is a very corrosive, poisonous liquid. If a battery is charged with a fast charger at a high rate for a period of time, the battery becomes hot and the sulfuric acid solution begins to boil. Under this condition, the battery may emit a strong sulfuric acid smell, and these fumes may be harmful to the lungs. If this condition occurs in the shop, the battery charger should be turned off, or the charger rate should be reduced considerably.

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WARNING: When an automotive battery is charged, hydrogen gas and oxygen gas escape from the battery. If these gases are combined, they form water, but hydrogen gas by itself is very explosive. While a battery is charged, sparks, flames, and other sources of ignition must not be allowed near the battery.

WARNING: Breathing asbestos dust must be avoided because this dust is a known contributor to lung cancer.

Some automotive clutch facings and brake linings contain asbestos. Never use an air hose to blow dirt from these components because this action disperses asbestos dust into the shop where it may be inhaled by technicians and other people in the shop. Parts washers approved by OSHA must be used to clean the dust from these components (Figure 1-24). Brake washer concentrate is mixed with water in these parts washers (Figure 1-25). A catch basin with a removable liner is placed under the parts to be washed, and the washer sprays the cleaning solution on the parts. After the washing operation is completed, the liner containing the cleaning solution and asbestos dust is removed, sealed, and labeled for proper handling and disposal according to waste disposal laws.

Even though technicians take every precaution to maintain air quality in the shop, some undesirable gases may still get in the air. For example, exhaust manifolds may get oil on them during an engine overhaul. When the engine is started and these manifolds become hot, the oil burns off the manifolds and pollutes the shop air with oil smoke. Adequate shop ventilation must be provided to take care of this type of air contamination.

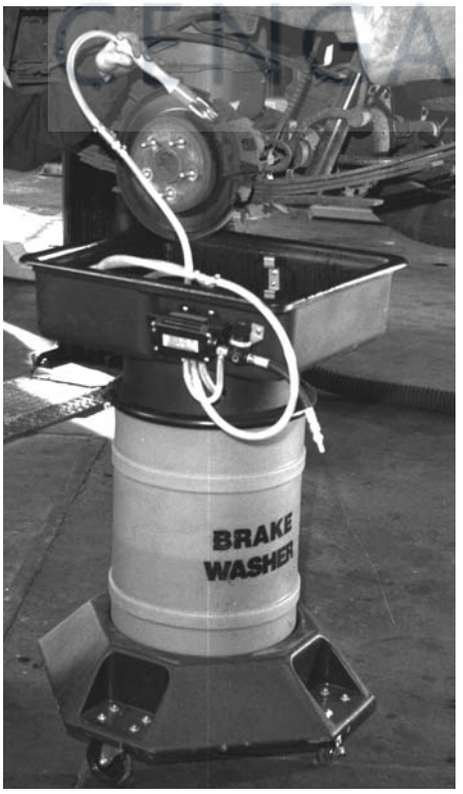

Figure 1-24 Brake assembly washer for asbestos dust.

Figure 1-25 Brake washer concentrate.

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Employer and Employee Obligations

When you begin employment, you enter into a business agreement with your employer. A business agreement involves an exchange of goods or services that have value. Although the automotive technician may not have a written agreement with his or her employer, the technician exchanges time, skills, and effort for money paid by the employer. Both the employee and the employer have obligations. The automotive technician's obligations include the following:

1. *Productivity.* As an automotive technician, you have a responsibility to your employer to make the best possible use of time on the job. Each job should be done in a reasonable length of time. Employees are paid for their skills, effort, and time.
2. *Quality.* Each repair job should be a quality job! Work should never be done in a careless manner. Nothing improves customer relations like quality workmanship.
3. *Teamwork.* The shop staff is a team and everyone, including technicians and management personnel, is a team member. You should cooperate with and care about other team members. Each member of the team should strive for harmonious relations with fellow workers. Cooperative teamwork helps to improve shop efficiency, productivity, and customer relations. Customers may be turned off by bickering between shop personnel.
4. *Honesty.* Employers and customers expect and deserve honesty from automotive technicians. Honesty creates a feeling of trust between technicians, employers, and customers.
5. *Loyalty.* As an employee, you are obliged to act in the best interests of your employer, both on and off the job.
6. *Attitude.* Employees should maintain a positive attitude at all times. As in other professions, automotive technicians have days when it may be difficult to maintain a positive attitude. For example, there will be days when the technical problems on a certain vehicle are difficult to solve. However, developing a negative attitude certainly will not help the situation! A positive attitude has a positive effect on the job situation as well as on the customer and employer.
7. *Responsibility.* You are responsible for your conduct on the job and your work-related obligations. These obligations include always maintaining good workmanship and customer relations. Attention to details such as always placing fender and seat covers on customer vehicles prior to driving or working on the vehicle greatly improve customer relations.
8. *Following directions.* All of us like to do things our way. Such action may not be in the best interests of the shop, and as an employee you have an obligation to follow the supervisor's directions.
9. *Punctuality and regular attendance.* Employees have an obligation to be on time for work and to be regular in attendance on the job. It is very difficult for a business to operate successfully if it cannot count on its employees to be on the job at the appointed time.
10. *Regulations.* Automotive technicians should be familiar with all state and federal regulations such as the OSHA and hazardous waste disposal laws pertaining to their job situation. In Canada, employees should be familiar with workplace hazardous materials information systems (WHMIS).

Employer-to-employee obligations include:

1. *Wages.* The employer has a responsibility to inform the employee regarding the exact amount of financial remuneration they will receive and when they will be paid.

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2. *Fringe benefits*. A detailed description of all fringe benefits should be provided by the employer. These benefits may include holiday pay, sickness and accident insurance, and pension plans.
3. *Working conditions*. A clean, safe workplace must be provided by the employer. The shop must have adequate safety equipment and first-aid supplies. Employers must be certain that all shop personnel maintain the shop area and equipment to provide adequate safety and a healthy workplace atmosphere.
4. *Employee instruction*. Employers must provide employees with clear job descriptions and be sure that each worker is aware of his or her obligations.
5. *Employee supervision*. Employers should inform their workers regarding the responsibilities of their immediate supervisors and other management personnel.
6. *Employee training*. Employers must make sure that each employee is familiar with the safe operation of all the equipment that they are required to use in their job situation. Since automotive technology is changing rapidly, employers should provide regular update training for their technicians. Under the right-to-know laws, employers are required to inform all employees about hazardous materials in the shop. Employees should be familiar with WHMIS, which detail the labeling and handling of hazardous waste and the health problems if exposed to hazardous waste.

Job Responsibilities

An automotive technician has specific responsibilities regarding each job performed on a customer's vehicle. These job responsibilities include:

1. Do every job to the best of your ability. There is no place in the automotive service industry for careless workmanship! Automotive technicians and students must realize they have a very responsible job. During many repair jobs, you, as a student or technician working on a customer's vehicle, actually have the customer's life and the safety of the vehicle in your hands. For example, if you are doing a brake job and leave the wheel nuts loose on one wheel, that wheel may fall off the vehicle at high speed. This could result in serious personal injury for the customer and others, plus extensive vehicle damage. If this type of disaster occurs, the individual who worked on the vehicle and the shop may be involved in a very expensive legal action. As a student or technician working on customer vehicles, you are responsible for the safety of every vehicle that you work on! Even when careless work does not create a safety hazard, it leads to dissatisfied customers who often take their business to another shop, and nobody benefits when that happens.
2. Treat customers fairly and honestly on every repair job. Do not install parts that are unnecessary to complete the repair job.
3. Use published specifications; do not guess at adjustments.
4. Follow the service procedures in the service manual provided by the vehicle manufacturer or an independent manual publisher.
5. When the repair job is completed, always be sure the customer's complaint has been corrected.
6. Do not be too concerned with work speed when you begin working as an automotive technician. Speed comes with experience.

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National Institute for Automotive Service Excellence (ASE) Certification

Automotive Service Excellence (ASE) has provided voluntary testing and certification of automotive technicians on a national basis for many years. The image of the automotive service industry has been enhanced by the ASE certification program. More than 265,000 ASE-certified automotive technicians now work in a wide variety of automotive service shops. ASE provides certification in these eight areas of automotive repair:

1. Engine repair
2. Automatic transmissions/transaxles
3. Manual drivetrain and axles
4. Suspension and steering
5. Brakes
6. Electrical systems
7. Heating and air conditioning
8. Engine performance

A technician may take the ASE test and become certified in any or all of the eight areas. When a technician passes an ASE test in one of the eight areas, an Automotive Technician's shoulder patch is issued by ASE. If a technician passes all eight tests, he or she receives a Master Technician's shoulder patch (Figure 1-26). Retesting at 5-year intervals is required to remain certified.

The certification test in each of the eight areas contains forty to eighty multiple-choice questions. The test questions are written by a panel of automotive service experts from various areas of automotive service, such as automotive instructors, service managers, automotive manufacturer's representatives, test equipment representatives, and certified technicians. The test questions are pretested and checked for quality by a national sample of technicians. Most questions have the Technician A and Technician B format similar to the questions at the end of each chapter in this book. ASE regulations demand that each technician must have 2 years of working experience in the automotive service industry prior to taking a certification test or tests. However, relevant formal training may be substituted for one of the years of working experience. Contact ASE for details regarding this substitution.

Shops that employ ASE-certified technicians display an official **ASE blue seal of excellence**. This blue seal increases the customer's awareness of the shop's commitment to quality service and the competency of certified technicians.

Figure 1-26 ASE certification shoulder patches worn by automotive technicians and master technicians.

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The ASE test Advanced Engine Performance Specialist L1 can only be taken by those technicians who are currently certified in Engine Performance (A8). The test is designed to identify those technicians who are knowledgeable in the areas of driveability and emissions-related diagnostics on automobiles, light trucks, and SUVs. The test is designed to test the technician's knowledge of PCM-controlled engine and emission control systems as well as the technician's ability to diagnose and repair the causes of emission failures.

ASE Advanced Engine Performance Specialist Test L1

Content Area	Questions in Test	Percentage of Test
General Powertrain Diagnosis	5	10%
Computerized Powertrain Diagnosis (Including OBD II)	13	26%
Ignition System Diagnosis	7	14%
Fuel Systems and Air Induction Systems Diagnosis	7	14%
Emission Control System Diagnosis	10	20%
I/M Failure Diagnosis	8	16%
Total	**50**	**100%**

Shop Projects to Enhance the Theories in Chapter 1 of the Classroom Manual

1. Strike the tread of an inflated tire with a rubber hammer. What reaction did you find? Why did this reaction occur?
2. Place some cold water in a graduated heat-resistant container supported on a metal stand, and record the exact quantity of water. Heat the water with a propane torch until it boils and record the exact quantity of water. What happened to the water when it was heated?
3. Obtain an empty metal 1-gallon container with a tight-fitting top. Place about 1 pint of water in the container and heat the container until the water is boiling. Then install the top securely and allow the container to cool. Cooling time may be reduced by placing ice on the container. What happened to the container? Why did this happen?
4. Obtain a vacuum hand pump and a vacuum advance from a distributor. Gradually operate the pump and observe the vacuum diaphragm. How much vacuum is required to begin moving the vacuum diaphragm? How much vacuum is required to move this diaphragm to the fully advanced position? What two forces move the diaphragm?

Guidelines for Following Proper Shop Practices

1. Technicians must be familiar with shop layout, especially the location of safety equipment. This knowledge provides a safer, more efficient shop.
2. Shop rules must be observed by everyone in the shop to provide adequate shop safety, personal health protection, and vehicle protection.

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3. The application of driving rules in the shop increases safety, protects customer vehicles and shop property, and improves the shop image in the eyes of the customer.
4. When good housekeeping habits are developed, shop safety is improved, worker efficiency is increased, and customers are impressed.
5. If some basic rules are followed to maintain shop air quality, the personal health of shop employees is improved.
6. When employers and employees accept and fulfill their obligations, personal relationships and general attitudes are greatly improved, shop productivity is increased, and customer relations are improved.
7. If a technician accepts certain job responsibilities, job quality improves, and customer satisfaction increases.
8. **ASE technician certification** improves the quality of automotive repair and improves the image of the profession.

CASE STUDY 1

A technician raised a vehicle on a lift to perform an oil and filter change including a chassis lubrication on a Grand Marquis. This lift was a twin post-type with separate front and rear lift posts. On this type of lift, the rear wheels must be positioned in depressions in the floor to position the rear axle above the rear lift arm. Then the front lift post and arms must be moved forward or rearward to position the front lift arm under the front suspension. The front lift arms must also be moved inward or outward so they are lifting on the vehicle manufacturer's specified lift points.

The technician carefully positioned the front lift post and arms properly, but forgot to check the position of the rear tires in the floor depressions. The car was raised on the lift, and the technician proceeded with the service work. Suddenly there was a loud thump and the rear of the car bounced up and down! The rear lift arms were positioned against the floor of the trunk rather than on the rear axle, and the lift arms punched through the floor of the trunk, narrowly missing the fuel tank. The technician was extremely fortunate the car did not fall off the lift, resulting in severe damage. If the rear lift arms had punctured the fuel tank, a disastrous fire could have occurred! Luckily, these events did not happen.

The technician learned a very important lesson about lift operation. Always follow all the recommended procedures in the lift operator's manual! The trunk floor was repaired at no cost to the customer, and fortunately the shop and the vehicle escaped without major damage.

CASE STUDY 2

A technician was removing and replacing the alternator on a General Motors car. After installing the replacement alternator and connecting the alternator battery wire, the technician proceeded to install the alternator belt. The rubber boot was still removed from the alternator battery terminal. While installing this belt, the technician's wristwatch expansion bracelet made electrical contact from the alternator battery terminal to ground on the alternator housing. Even though the alternator battery wire is protected with a fuse link, which melted, a high current flowed through the wristwatch bracelet. This heated the bracelet to a very high temperature and severely burned the technician's arm.

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This technician forgot two safety rules:

1. Never wear jewelry, such as watches and rings, while working in an automotive shop.
2. Before performing electrical work on a vehicle, disconnect the negative battery cable. If the vehicle is equipped with an air bag, wait 1 minute after this cable is disconnected.

CASE STUDY 3

A technician was removing and replacing the starting motor with the solenoid mounted on top of the motor. The technician began removing the battery cable from the solenoid, and the ring on one of his fingers made contact between the end of the wrench and the engine block. The current flow through the ring was so high that the positive battery terminal melted out of the battery. The technician's finger was so badly burned that a surgeon had to cut the ring from his finger and repair the finger.

This technician forgot to disconnect the negative battery cable before working on the vehicle!

CASE STUDY 4

A technician had just replaced the engine in a Ford product, and she was performing final adjustments such as timing and air-fuel mixture. In this shop, the cars were parked in the work bays at an angle on both sides of the shop. With the engine running at fast idle, the automatic transmission suddenly slipped into reverse. The car went backwards across the shop and collided with a car in one of the electrical repair bays. Both vehicles were damaged to a considerable extent. Fortunately, no personnel were injured.

This technician forgot to apply the parking brake while working on the vehicle!

Terms to Know

Asbestos dust vacuum cleaner
ASE blue seal of excellence
ASE technician certification
Shop layout

ASE-Style Review Questions

1. While discussing shop hazards:
Technician A says high-pressure air from an air gun may penetrate the skin.
Technician B says air in the bloodstream may be fatal.
Who is correct?
A. A only
B. B only
C. Both A and B
D. Neither A nor B

2. While discussing shop rules:
Technician A says breathing carbon monoxide may cause arthritis.
Technician B says breathing carbon monoxide may cause headaches.
Who is correct?
A. A only
B. B only
C. Both A and B
D. Neither A nor B

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3. While discussing shop rules:
Technician A says breathing asbestos dust may cause heart defects.
Technician B says oily rags should be stored in uncovered garbage containers.
Who is correct?
A. A only **C.** Both A and B
B. B only **D.** Neither A nor B

4. While discussing hazardous waste disposal:
Technician A says the right-to-know laws require employers to train employees regarding hazardous waste materials.
Technician B says the right-to-know laws do not require employers to keep permanent records regarding hazardous waste materials.
Who is correct?
A. A only **C.** Both A and B
B. B only **D.** Neither A nor B

5. While discussing material safety data sheets (MSDS):
Technician A says these sheets explain employers' and employees' responsibilities regarding hazardous material handling and disposal.
Technician B says these sheets contain specific information about hazardous materials.
Who is correct?
A. A only **C.** Both A and B
B. B only **D.** Neither A nor B

6. While discussing air quality:
Technician A says a battery gives off hydrogen gas during the charging process.
Technician B says a battery gives off oxygen gas during the charging process.
Who is correct?
A. A only **C.** Both A and B
B. B only **D.** Neither A nor B

7. While discussing air quality:
Technician A says diesel exhaust contains particulates.
Technician B says particulate emissions contain oxides of nitrogen.
Who is correct?
A. A only **C.** Both A and B
B. B only **D.** Neither A nor B

8. While discussing employer and employee responsibilities:
Technician A says employers are required to inform their employees about hazardous materials in the shop.
Technician B says that employers have no obligation to inform their employees about hazardous materials in the shop.
Who is correct?
A. A only **C.** Both A and B
B. B only **D.** Neither A nor B

9. While discussing hazardous materials:
Technician A says a solid that ignites spontaneously is considered a hazardous material.
Technician B says a liquid with a flash point below 140°F (60°C) is considered a hazardous material.
Who is correct?
A. A only **C.** Both A and B
B. B only **D.** Neither A nor B

10. While discussing hazardous waste disposal:
Technician A says hazardous waste materials may be hauled to an approved hazardous waste disposal site or recycled in the shop.
Technician B says all hazardous waste materials must be hauled to an approved hazardous waste disposal site.
Who is correct?
A. A only **C.** Both A and B
B. B only **D.** Neither A nor B

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